

# The genus *Cuernavaca* (Hemiptera: Dictyopharidae), associated with Pontederiaceae in South America, with redescription and new records of *C. inexacta* (Walker)

Ana María Marino de Remes Lenicov<sup>1</sup>; María Cristina Hernández<sup>2,3</sup>; Alejandro Joaquín Sosa<sup>2,4</sup> & Marina Inés Oleiro<sup>2,5</sup>

<sup>1</sup> Universidad Nacional de La Plata (UNLP), Facultad de Ciencias Naturales y Museo (FCNyM), División Entomología. La Plata, Buenos Aires, Argentina. ORCID: <http://orcid.org/0000-0001-8678-5408>. E-mail: [marinoremes@gmail.com](mailto:marinoremes@gmail.com)

<sup>2</sup> Fundación para el Estudio de Especies Invasivas (FuEDEI). Hurlingham, Buenos Aires, Argentina.

<sup>3</sup> ORCID: <http://orcid.org/0000-0003-4382-773X>. E-mail: [crishernandez@fuedei.org](mailto:crishernandez@fuedei.org)

<sup>4</sup> ORCID: <http://orcid.org/0000-0002-1680-8712>. E-mail: [alejsosa@fuedei.org](mailto:alejsosa@fuedei.org)

<sup>5</sup> ORCID: <http://orcid.org/0000-0002-5699-5196>. E-mail: [oleirom13@gmail.com](mailto:oleirom13@gmail.com)

**Abstract.** The aim of this paper is to shed light on the boundaries of two sympatric species of *Cuernavaca*, *C. inexacta* and *C. longula*, to enable further ecological studies. Species in this genus are associated with water hyacinths in wetlands of Northeastern Argentina (Paraná-Paraguay waterway system) and the Peruvian Amazon. This work lists new host records for *Cuernavaca*, which include *Pontederia crassipes*, *P. cordata*, *P. subovata* and *P. rotundifolia* (Pontederiaceae). A redescription for *C. inexacta* with new diagnostic genitalic features is also provided, as well as an updated identification key and a distribution map. The genus is distributed throughout Central and South America, reaching north and central Argentina in its southernmost distribution.

**Key-Words.** *Cuernavaca*; Auchenorrhyncha; Dictyopharinae; Water hyacinth; Neotropical wetlands.

## INTRODUCTION

Dictyopharidae is the 6<sup>th</sup> largest family of planthoppers (Bartlett, 2018; Bourgoin, 2016; Song *et al.*, 2014, 2016a, 2016b, 2018; Urban & Cryan, 2009). It is mainly distributed in tropical and subtropical regions, and it currently includes two subfamilies: the Orgeriinae (192 species, 52 genera and subgenera within 4 tribes), which is restricted to arid zones of the Holarctic region, and the cosmopolitan and diverse Dictyopharinae, comprising more than 520 species and 127 genera within 15 tribes (Song *et al.*, 2018).

Taxonomic revisions of Dictyopharinae have been published at the generic and suprageneric levels (Fennah, 1945; Melichar, 1912; Muir, 1923) but Emeljanov (1969, 1983, 1997, 2008, 2010, 2011, 2014) was the first to contribute to higher-level phylogenetic studies in the group. Within the eight tribes defined by Emeljanov (1983), the monogeneric Taosini is widely represented in tropical America. *Taosa* (Distant, 1906), was initially revised by Muir (1931), who distinguished 12 species based on the shape and carination of head. Metcalf (1945) established *Cuernavaca* Kirkaldy (1913) as a subgenus of *Taosa* to in-

clude *Dictyophara herbida* (Walker, 1851) whereas Fennah (1945) considered *Cuernavaca* as a synonym of *Taosa*, emphasizing the taxonomic value of the male genitalia and also the importance of the first female valvulae for species recognition. Synave (1969) and Donovall (2008) also provided full descriptions and taxonomic remarks on the species of *Taosa* earlier recognized. Later, Emeljanov (2011) redefined Taosini mainly by the presence of trigones on the head and the visibility of frons in dorsal view and included six genera: *Brachytaosa* Muir (Muir, 1931); *Netaosa* Emeljanov (Emeljanov, 2011); *Phormotegus* Emeljanov (Emeljanov, 2010); *Sicorisia* Melichar (Melichar, 1912); *Taosa* and *Cuernavaca*.

Recently, Song *et al.* (2018) presented a valuable contribution on the tribe-level phylogeny of Dictyopharidae, which supports the monophyly of 12 tribes (except Taosini + Lappidini whose limits have not been clearly established yet). This phylogenetic analysis indicates that Taosini is paraphyletic with *Netaosa* sister to the combination of *Cuernavaca*, *Taosa* and the tribe Lappidini, placing *Cuernavaca* and *Taosa* into Taosini s.s. The genus *Cuernavaca* currently embraces three species: *C. inexacta* (Walker) [= *T. inexacta* Walker (Walker,

Pap. Avulsos Zool., 2020; v.60: e20206011

<http://doi.org/10.11606/1807-0205/2020.60.11>

<http://www.revistas.usp.br/paz>

<http://www.scielo.br/paz>

Edited by: Cristiano Feldens Schwertner

Received: 15/04/2019

Accepted: 04/12/2019

Published: 06/02/2020

ISSN On-Line: 1807-0205

ISSN Printed: 0031-1049

ISSN: 0000-0004-0384-1825



1858), *C. longula* (Remes Lenicov) [= *T. (C.) longula* Remes Lenicov (Remes Lenicov & Hernández, 2010)] and *C. herbida* (Walker) [= *T. herbida* (Walker) (Walker, 1851)].

Dictyopharids are known to feed predominantly on a variety of dicotyledonous herbs, with a few species recorded on monocots (Bourgoin, 2016; Denno & Perfect, 1994; Wilson et al., 1994; Wilson & O'Brien, 1987). This group also include a few species that are agricultural pests of significant economic importance (Bourgoin, 2016; Krstić et al., 2016). Information on host plant associations and the effects caused by the herbivory of *Cuernavaca* species is fragmented (Hernández et al., 2011a, b; Maes & O'Brien, 1988; Sacco et al., 2013). In South America, *Cuernavaca inexacta* was regarded by Bennett & Zwolfer, 1968 as a potential biocontrol agent of the water hyacinth *Pontederia crassipes* Martius (Pontederiaceae) [ex *Eichhornia crassipes* (Mart.) Solms-Laub. (Pellegrini et al., 2018)]. Our taxonomic assessment of *Cuernavaca* associated with water hyacinths revealed that *C. longula* coexist with other related species from the upper Amazon River (Remes Lenicov & Hernández, 2010; Remes Lenicov et al., 2012). These species are sympatric in part of their distribution, and should be properly distinguished among themselves so their potential as biocontrol agents can be more thoroughly explored. Therefore the aim of this paper is to redescribe *C. inexacta* in detail, incorporating new diagnostic characters of the male and female genitalia, and updating a key to the species of *Cuernavaca*, as well as distribution and host plant associations.

## MATERIAL AND METHODS

### Examined specimens

The taxonomic assessment presented here was mainly based on primary types and secondary types, but also included specimens listed in the original descriptions or identified by renowned specialists in the field. Additional specimens were specifically collected in wetlands of Northeastern Argentina (in the Paraná and Paraguay rivers basin) and the Peruvian Amazon. We used a sweeping net or manual techniques on natural mats of free-floating aquatic species: *P. crassipes*, *P. cordata* L., *P. subovata* (Seub.) Lowden and *P. rotundifolia* L. Specimens studied in the course of this work are deposited in the following institutions, which are subsequently referred to by their acronyms: British Museum of Natural History (BMNH), London, UK; Muséum National d'Histoire Naturelle (MNHN), Paris, France and Museo de Ciencias Naturales de La Plata (MLPA), Argentina.

### Morphological studies

Specimens were killed in 95% ethyl ether to preserve their coloration. Genital segments were dissected and cleared in 10% KOH at room temperature for ca. 24-48 hours, rinsed and immersed in distilled water, then trans-

ferred to 10% glycerol microvials for long-term storage. Dissections from the male and female genitalia were fixed in Faure's medium for morphological analysis and illustration, according the procedures outlines in Remes Lenicov & Hernández (2010). Observations, measurements and pictures were made using a stereomicroscope LEICA EZ5 and a RRID 18 HD digital camera. Digital images were assembled using Combine ZM open software (Hadley, 2011) and improved with the Adobe Photoshop CS5 software.

Morphological terminology and measurements follow Song et al. (2016a, b) for the majority of characters, Bourgoin et al. (2015) for tegmina venation, and Bourgoin (1993) for female genitalia. Reported measurements (median and range) were taken from 10 specimens of each sex and are given in millimeters.

### Abbreviations on each measurement are as follows:

L. = total length (from apex of head to apex of forewings); B.L. = body length (from apex of head to tip of abdomen); W.L. = forewing length. One additional measurement is relative; length: width ratio (L:W) of the vertex, which was measured along the vertex midline and near its mid-length respectively.

A distribution map of *Cuernavaca* species was assembled with QGIS 3.02 using literature records and from the material examined; new distributional records are marked with an asterisk (\*).

## RESULTS

### Taxonomy

#### *Cuernavaca* Kirkaldy, 1913

Morphological and phylogenetic studies given by Emeljanov, 2011 and Song et al., 2018, respectively, show that *Cuernavaca* and *Taosa* are closely related. *Cuernavaca* may be separated from the latter by the following characters: head relatively short, frons broad not visible in dorsal view, tegmina membranous with a second rank of postnodal closed cell on membrane; female with ovipositor elongate, anterior connective lamina of gonapophysis VIII with 12 or more small, longitudinally arranged teeth, gonoplares extremely elongate and narrow with a bunch of long setae near apex on ventral lobe.

The three species presently included in this genus can be distinguished by the following key.

#### Key to species of *Cuernavaca* (Modified from Remes Lenicov & Hernández, 2010: 334)

1. Uniformly green with a pair of small dark spots on each side of mesonotum; male with gonostyles shorter than anal segment, suboval; females with strongly elongated anal segment, 5 times its width; long and straight gonapophyses VIII with a row of strong

- bifurcate teeth on dorsal margin (Remes Lenicov & Hernández, 2010: Figs. 1-3, p. 335-337) ..... *C. longula* (Remes Lenicov)
- Green with orange to dark brown marks on basal frons; male with gonostyles equal to longer than anal segment, elongate; females with relatively short anal segment 1.5 times its width; short and sinuate gonapophyses VIII, not surpassing anal segment, with conical dorsal teeth in two rows ..... 2
2. Frons with broad longitudinal orange band on submedian carinae in basal half; vertex longer than broad across base; gonostyles elongate, gradually narrowing to the obtusely pointed apex, dorsal margin angular on basal half, upper tooth longer than the basal tooth, with straightly forward position; endosomal processes of phallobase lanceolate and apically acute (Fig. 1E); gonapophyses VIII with two subparallel and subequal row of acute teeth (Fig. 1F) ..... *C. inexacta* (Walker)
- Frons with longitudinal orange band, blackish at base; vertex broader than long across base; gonostyles elongate, dorsal margin concavely sloping toward apex, ending in a small blunt lobe; upper tooth curved forward; endosomal processes of phallobase regularly slender tapering toward apex; gonapophyses VIII with two unequal rows of teeth (Fennah, 1945: pl. 12, p. 293, 297) ..... *C. herbida* (Walker)

## Plant associations

***Cuernavaca inexacta*:** There were records of potential host plants (sugarcane, water hyacinth) but the specimens' identification was not clearly stated (Bennett & Zwolfer, 1968; Center et al., 2002; Crutwell, 1973; Fennah, 1945). In our studies, it was found on *P. crassipes*, *P. cordata*, *P. rotundifolia* and *P. subovata*, which represent new host records.

***Cuernavaca longula*:** It was described as the first Dictyopharinae species associated to *P. crassipes* from Argentina and studied as a candidate of biocontrol of this weed because of its narrow host range in the *Pontederia* spp. (Pontederiaceae) (Hernández et al., 2011a; Remes Lenicov & Hernández, 2010).

***Cuernavaca herbida*:** The only known host plant association is with Liberian coffee in Trinidad (Fennah, 1945).

## Field observations

Representatives of the genus collected on *P. crassipes* in several sites in Peru and Argentina, show that *C. inexacta* and *C. longula* occupy similar ecological habitats, although *C. inexacta* was more abundant in the wetlands of the Peruvian Amazon than in the Paraná-Paraguay fluvial wetlands system. The Argentine wetlands drain into the Rio de La Plata river basin that is the southern border of the native range of the Pontederiaceae species and also of the *Cuernavaca* species.

### ***Cuernavaca inexacta* (Walker, 1858) (Figs. 1A-G; 2A, B)**

*Dictyophora inexacta* Walker, 1858: 38, synonymized with *T. herbida* by Muir, 1931: 474.

*Taosa paraherbida* Muir, 1931: 474, synonymized by Fennah, 1947: 9.

*Taosa* (*Cuernavaca*) *paraherbida* Muir, 1931, according to Metcalf, 1946: 110.

*Taosa inexacta* (Walker, 1858) restored by Fennah, 1947: 9. *Cuernavaca inexacta* (Walker, 1858) according to Emeljanov, 2011: 1123; Song et al., 2018: 13.

**Emended diagnosis:** General color green, slightly tinged reddish brown band overlying submedian frontal carina and base of ocelli. Tegmina and hindwings clear hyaline with green veins; pterostigma opaque yellowish. Body elongate; head with narrow vertex, slightly longer than wide across base, projected for more than half its length in front of eyes, median carina evanescent in apical half, transverse carina anteriorly bounding well-defined trigones, separated from preocular areas by slightly sinuous carina, sharp apices distant from midline; frons long, lateral margins slightly parallel in basal half, barely expanded in apical third; rostrum extending past basal third of hind femora in repose.

**Male:** Anal segment ventrally covering apex of gonostyles; gonostyles slender, longer than wide, narrowing at base in ventral view, upper margin slightly angular on basal half and gradually narrowing to the apex, with a distinctive long straight process dorso cephalad directed, apically obtuse, and a small ventro caudad curved hook-like process near sub-middle on the outer edge, in lateral view; aedeagus ending in a pair of long sinuous ventro-apical curved spinose processes dorsocaudally directed; phallobase tubular with a pair of slender and apically lanceolated endosomal processes emerging abruptly cephalad in their apical fourth. Segment X distinctly elongate, anal style far beyond apical ventral margin of segment X.

**Female:** Anal segment relatively short, just above the ovipositor; ovipositor short and strong; gonapophyses VIII (first valvulae) strong, slightly curving upward to apex, anterior connective lamina with about 24 uneven teeth decreasing in size toward base arranged in double row running subparallel in the dorsal margin. Gonopods (third valvulae) slightly elongated, the ventral lobe with a narrow densely hairy area along lower margin and a tuft of short stout hairs at apex. Segment X oval to elongate; anal style far beyond apical ventral margin of segment X. Female ectodermal genital ducts ditrysian, surrounding area of copula poris distinguishably colored.

## Redescription

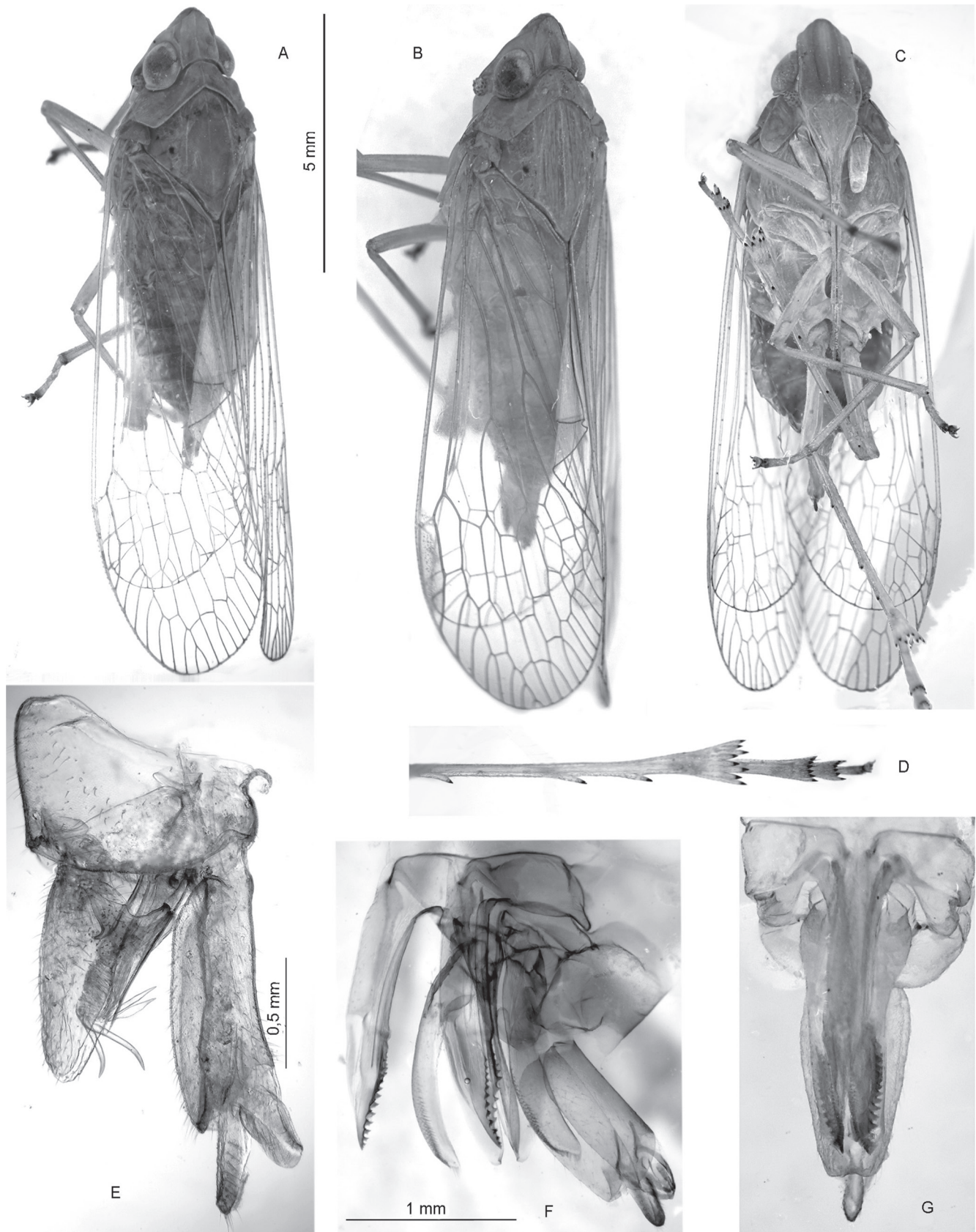
**Body (Fig. 1A-C):** Ground color uniformly green, with slightly tinged reddish brown bands overline submedian frontal carina and around ocelli. Tegmina and wings clear hyaline with green veins; pterostigma opaque yellowish.

**Head:** Vertex narrow in dorsal view, little longer than broad across base (1.1:1), apical margin broadly angulate, projecting in front of eyes by more than half its



length, on the same plane in relation to pronotum; lateral carinae slightly ridged in front of eyes, sub-parallel at base and gradually convergent anteriorly; basal margin

rather shallowly round excavated between eyes, basal width nearly twice the diameter of eyes, median carina incomplete, only distinct in base; transverse carina dor-



**Figure 1.** *Cuernavaca inexacta* (Walker) (MLPA) Male: (A) habitus, dorsolateral view; (E) genito-anal segments, left lateral view. Female: (B) habitus, dorsolateral view; (C) ventral view; (D) apex of hind leg (post tibial apical teeth and tarsi); (F) genito-anal segments, left lateral view; (G) genito-anal segments, ventral view. Scale bars: A-D: 5 mm; E: 0.5 mm; F-G: 1 mm.

sally bounding the well-defined subtriangular trigones, separated from preocular areas by a slightly sinuous carina, sharp apices distant from the mid line. Frons relatively short, in the middle a little longer than wide at maximum width (1.3:1), linear, with lateral margins slightly parallel in the basal half, barely expanded in the apical third, carinae distinct, without carina between apex of lateral and intermediate carinae, the median complete and very feeble, the intermediates subparallel, nearly straight, weakly ridged, evanescent next to frontoclypeal suture, laterals strongly ridged; apical margin deeply excavated and inverted V-shaped. Clypeus longer than wide at base (2.1:1), surpassing apex of fore coxae, laterals and median carina distinctly elevated, median extended to apex (Fig. 1C). Labrum free, elongate; rostrum relatively long, surpassing basal third of hind femora, basal segment longer than apical (1.3:1) reaching apices of hind coxae. Compound eyes long oval. Ocelli present.

**Thorax:** Pronotum wider than head (1.3:1), shorter than vertex at midline (0.5:1); carinae distinctly ridged, median carina percurrent, intermediate carinae distinct in basal third to half, curved closely behind the eyes, with a prominent slightly curved downwards carinae on paranotal lobes not reaching rear edge; anterolateral angles rounded, anterior central margin arcuately convex, posterior margin deeply concave. Mesonotum medially more than six times the length of the pronotum, carinae distinct, extinct at the scutellum, the laterals slightly divergent, feebly incurved basally not reaching median carina; tegmina membranous extending beyond the abdomen, with ratio length to maximum width 3:1; hyperpterous in R, MP and CuA., with a second rank of post-nodal closed cells after the nodal cells; pterostigma narrow three-celled. Hind tibiae with 4 lateral black-tipped spines and 8 apical black-tipped teeth; hind tarsomeres I as long as II and III together, tarsomere I and II with seven black-tipped apical teeth, respectively (Fig. 1D).

**Male genitalia (Fig. 1E):** Pygofer in lateral view distinctly longer ventrally than dorsally (4:1), more than twice ventral width; caudal margins rounded, slightly expanded ventrally; dorsal margin straightly excavated to accommodate segment X; ventral margin narrowly truncate. Gonostyles relatively large, slender; in lateral view with base narrow, strongly expanded in the middle and gradually narrowed towards rounded blunt apex; upper margin slightly angular at basal half, with a long lightly compressed straight hook-like process forward directed, apically obtuse; outer upper edge with a small ventro caudad curved spine near sub-middle. Aedeagus with phallosome tubular, slightly sclerotized at base and laterally, the remainder membranous with pair of inflatable membranous lobes, ending in slender ventro-apical spinose processes dorso-caudally directed and downward recurved at apex; phallobase tubular with a pair of slender and apically lanceolate endosomal processes extending posteriorly below theca and folding abruptly cephalad in their apical fourth. In lateral view, ventro-apical spinose processes of aedeagus reaching apex

of gonostyles and ventrocaudad angle of segment X at rest. Connective slender, elongate and slightly sclerotized, extending obliquely from the base of aedeagus to the base of by: Segment X as long as the length of style in lateral view; in dorsal aspect distinctly elongate, distal portion deeply medially emarginated, with ratio of length to width 2.5:1; in lateral view dorsal and ventral margins straight, the latter slightly longer in lateral view (1.1:1); apex obliquely truncate; anal style (Epr and Ppr) relatively short extended more than the half of its length beyond apical ventral margin.

**Female (Fig. 1B):** Similar to male in body morphology and coloration.

**Genitalia (Figs. 1F, G):** Short and strong ovipositor; anal segment relatively short, reaching apex of ovipositor at rest. Gonocoxa VIII (1<sup>st</sup> valvifer) triangular, vertically placed, gonapophyses VIII (1<sup>st</sup> valvulae) subelliptical in lateral view, dorsal border smoothly and slightly curved, ventral border slightly convex to dorsum, both dorsal and ventral margins narrowing sharply in the apical half, slightly curving upward to apex; anterior connective lamina with subparallel double rows of unequal teeth on dorsal margin, each one consisting of about 10 to 11 sharp teeth, almost same-sized, lightly descending in size toward base. Gonapophyses IX, elongate and narrow. Gonopods (3<sup>rd</sup> valvulae) with both lobes subequal in length, as long as anal segment, subparallel sided, ventral lobe rounded at apex, with lower margin convex strongly curving upward to apex, with a densely hairy area along lower edge in apical half and a tuft of rigid hairs at tip; dorsal lobe slender truncate at apex, strongly reflected inward. Segment X longish ovate, distal portion deeply medially emarginated, with ratio of length to width 2:1; in lateral view dorsal and ventral margins straight, the latter slightly longer in lateral view (1.1:1); apex slightly truncate; anal style (Epr and Ppr) relatively short extended more than half of its length beyond apical ventral margin. Ectodermal genital ducts ditrysian; copulapores area darkish colored, corresponding to the inner esclerotized vaginal plates, visible through translucent skin, more evident in cleared specimens.

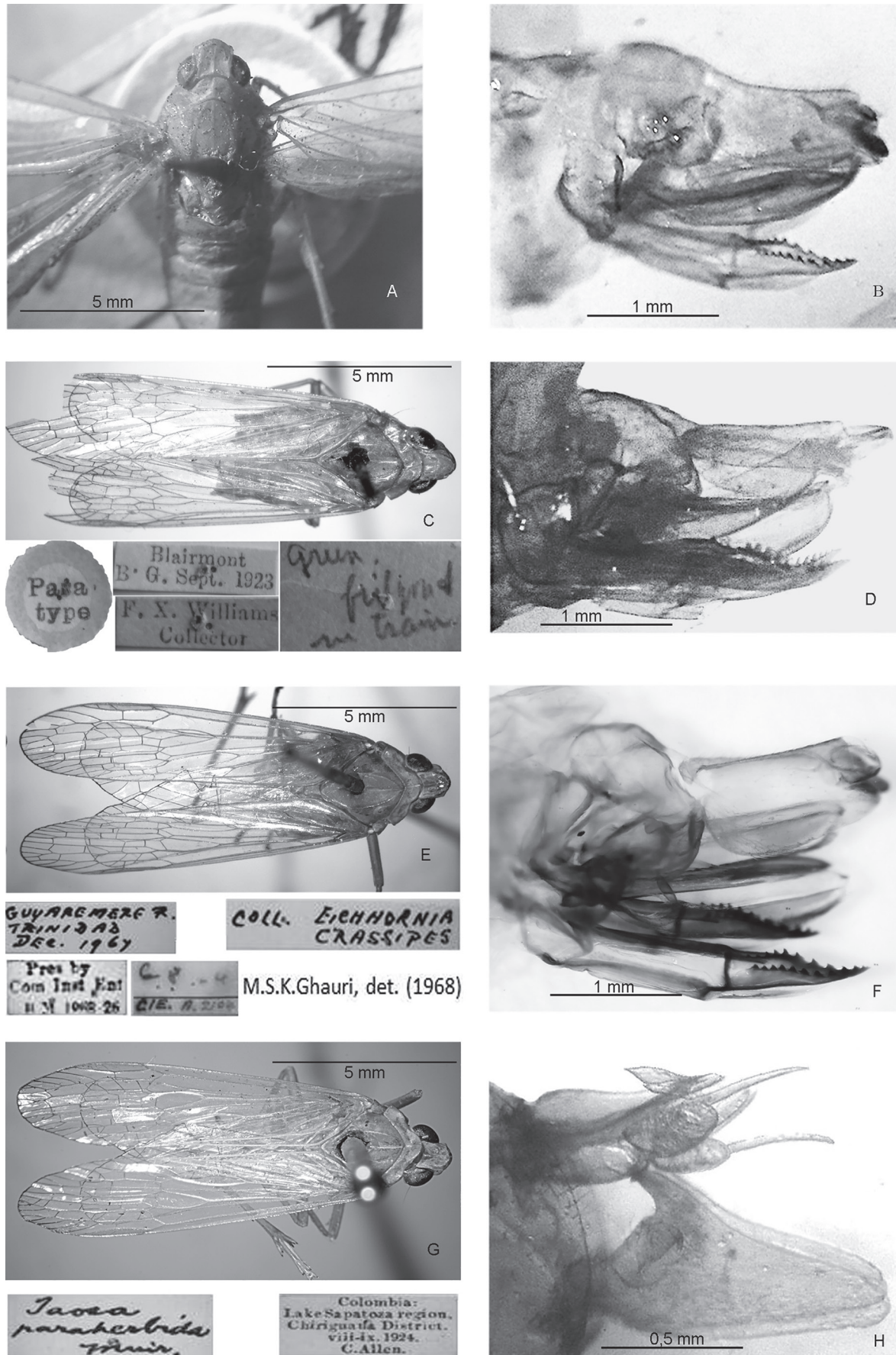
**Measurements:** L: male, 11.1 (11-11.3), female, 12.1 (11.6-12.6); B.L: male, 7.75 (7.7-7.8), female, 9.5 (9.6-10); W.L: male, 9.7 (9.5-10), female, 10.2 (10-10.3).

### Taxonomic remarks

*Cuernavaca inexacta* differs from its congeners in its coloration pattern and head traits. The most distinctive features of the male genitalia are the combination of the angular profile of gonostyle, the longest and slender processes in the aedeagal complex and the endosomal processes. Whereas in female, the distinctive feature is the numerous teeth arranged in two subequal and sub-parallel rows on gonapophyses VIII.

*Cuernavaca inexacta* can be easily distinguished from the sympatric *C. longula*, known to occur in the same





**Figure 2.** *Dictyophara inexacta* Walker (BMNH) Holotype female: (A) habitus, dorsal view; (B) genito-anal segments, left lateral view. *Taosa paraherbida* Muir (BMNH), Paratype female: (C) habitus, dorsal view and their labels; (D) genito-anal segments, left lateral view. *Taosa inexacta* (Walker) (BMNH), Female: (E) habitus, dorsal view and their labels; (F) genito-anal segments, left lateral view; *Taosa paraherbida* Muir (BMNH), Male: (G) habitus, dorsal view and their labels, (H) genital segment, left lateral view. Scale bars: A, C, E, G: 5 mm; B, D, F: 1 mm; H: 0.5 mm.

habitats and feed on the resources in several areas of South America, by the smaller size, the reddish brown coloration on the base of frons and around base of ocelli, the longer vertex, the frons not so strongly expanded near apex, the gonostyles wider at middle in lateral view with straight and forward directed hook-like process, and the more slender, longer and different shaped aedeagal and endosomal processes in male, and the female by the distinctly shorter anal segment and ovipositor, the greater number of teeth lying in two rows on the anterior connective lamina of gonapophyses VIII and the darkish coloration on the copulapophyses area.

Female genitalia of *Cuernavaca inexacta* is redescribed and redefined based on examination of the Holotype of *Dictyophara inexacta* Walker (Figs. 2A, B), the paratype female of *Taosa paraherbida* Muir (specimen designed as residual type by Fennah, 1947: 9) (Figs. 2C, D), and 1 female of *Taosa inexacta* (Walker) from Guyarmare, Trinidad, Ghauri det. (Figs. 2E, F) (all in BMNH). We observed that the anterior connective lamina of the gonapophyses VIII have two subequal and subparallel rows of teeth dorsally, each with 10 to 11 sharp denticle. These features contrast with those erroneously described and illustrated by Fennah (1945) for *T. paraherbida* Muir as follow: "First valvulae narrow, sinuate, with a row of eight stout, short, triangular teeth on dorsal margin, with a point at apex". In the remaining features specimens match the original description in every detail; probably the double row of denticles might not have been observed by the author from a side view (p. 464, pl. 12, fig. 306).

Examination of one male specimen of *Taosa paraherbida* bearing Muir's identification label from Colombia (BMNH) (Figs. 2G, H) as well as those field collected specimens from Peru and Argentina, allowed us to provide a more complete description. We also noticed very little intraspecific variation in color and morphology among the adults in both sexes.

## Distribution

According to previously published records and voucher specimens from the BMNH, MNHN and MLPA, the three species of *Cuernavaca* are distributed over Central and South America, reaching north and central Argentina in the southernmost distribution (Fig. 3).

***Cuernavaca inexacta*:** Colombia (Walker, 1858); Guyana (Muir, 1931) and Trinidad (Fennah, 1945). New records: Panamá (Canal Zone, Gamboa), Venezuela (Etat de Guarico), Peru (Dto Loreto) and Argentina: Formosa, Chaco.

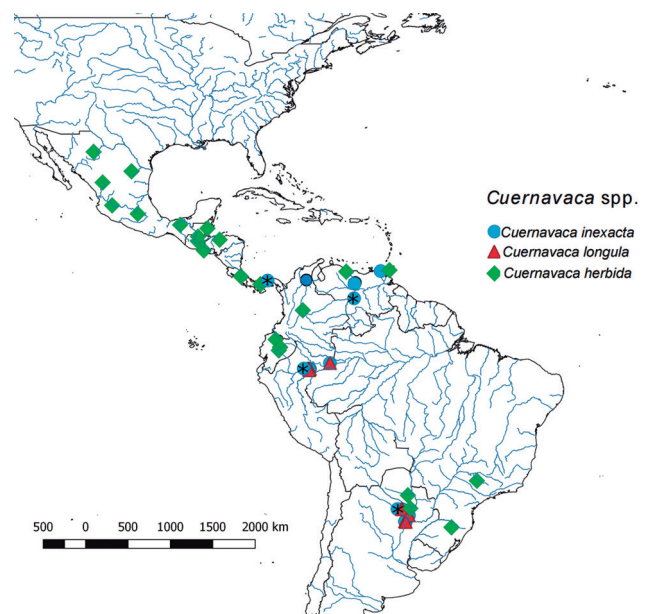
***Cuernavaca longula*:** Argentina Northeast (Formosa y Chaco) (Remes Lenicov & Hernández, 2010; Hernández et al., 2011b; Remes Lenicov et al., 2012) Brazil West-Central (Mato Grosso do Sul and Perú (Remes Lenicov & Hernández, 2010; Remes Lenicov et al., 2012).

***Cuernavaca herbida*:** Trinidad-Tobago (Walker, 1851); Costa Rica (Matina), Ecuador (Tena) and Brazil Southeast

(São Paulo, Dumont, Piracicaba) (Muir, 1931); Trinidad (St. Augustine) and Venezuela (Ocumare de la Costa) (Fennah, 1945); Mexico: Morelos (Cuernavaca), Nuevo Leon (Monterrey), Chihuahua; Ecuador: Napo Pastaza; Guatemala; British Honduras; Nicaragua; Costa Rica; Panamá; Central America; Colombia; Venezuela; Brazil; Paraguay; Argentina and South America (Metcalf, 1946).

## Material examined

***Cuernavaca inexacta* (Walker):** Holotype female of *Dictyophara inexacta* Walker, 1858, Colombia; Paratype female of *Taosa paraherbida* Muir, 1931, Blairmont B.G., September 1923, F.X. Williams col.; 1 male, *Taosa paraherbida* Muir, Colombia, Lake Sapatozoa, Chiriguana District, VIII-IX-1924, C. Allen col. (Muir's handwriting), Muir det.; 1 female of *Taosa inexacta* (Walker), Guyarmare, Trinidad, on *P. crassipes*, Dic. 1964, Ghauri det.; 1 male, Guyarmare, Trinidad, on *P. crassipes*, 1967; 1 male and 1 female, Canal Zone, Gamboa, Panama, Chagres R. at night, on *P. rotundifolia*, 30-VI-1974, C and L O'Brien and Marshall col.; 3 male, 1 female and 1 nymph V, unidentified, Guyarmare, Trinidad, on *P. crassipes*, Dic. 1967. (BMNH); 1 male, Venezuela, Etat de Guarico. La Cruz-Ruviera; M. Grisol, 1925; December; MNHN (EH) 18726; 1 male, Venezuela, Etat de Guarico. Camagua; M. Grisol, 1923; MNHN (EH) 18727; 1 male and 1 female, Colombia; 27-XI-1996; G. Lecourt; MNHN (EH) 18728-29, (MNHN). **PERU:** 6 males and 10 females, Montoya, 04°31'00"S, 73°32'23"W, on *P. crassipes*, 03-05-1999, Cordo col.; 3 males and 5 females, Iquitos, Montoya Cocha, 04°31'00"S, 73°32'23"W, on *P. crassipes*, 03-05-1999, Cordo col.; 3 males and 3 females, Perú, on *P. cordata*, 15-11-2001, Cordo col.; 1 female, Tacunare/Nacita, 12°16'22.33"S, 76°53'26.36"W, on *P. crassipes*, 15-11-2001, Cordo col.; 1 female and 8 nymphs, Morana, Morana; 04-11-2001, Cordo



**Figure 3.** Distribution map of *Cuernavaca* species based on records from the literature and examined specimens. Localities are listed in the corresponding document; new distributional records are marked with an asterisk (\*).



col.; 2 males, Iquitos, Carmen Cocha, 03°44'37.22"S, 73°15'05.88"W, on *P. crassipes*, 02-05-1999, Cordo col.; 5 males and 20 females, Montoya Cocha, 04°31'00"S, 73°32'23"W, on *P. crassipes*, 01-05-1999, Cordo col.; 1 female, Montoya Cocha, 04°31'00"S, 73°32'23"W, on *P. rotundifolia*; 03-05-1999, Cordo col.; 3 males and 3 females, Iquitos, Tipashira Cocha, 04°18'45"S, 73°19'32"W, on *P. crassipes*, 30-04-1999, Cordo col.; 5 males, Iquitos, Peruru Cocha, 04°16'51"S, 73°17'03"W, on *P. crassipes*, 29-04-1999, Cordo col.; 1 male and 1 female, Yanayacu River, 04°19'29"S, 73°18'11"W, on *P. rotundifolia*, 30-04-1999, Cordo col.; 7 males and 4 females, Yarapa Yarapa, 04°28'56"S, 73°23'39"W, on *P. crassipes*, 13-11-2001, Cordo col.; 1 male, Tacunare/Nacita, on *P. crassipes*, 14-11-2001, Cordo col., 4 males and 4 females, Norte Caño, on *P. crassipes*, 14-11-2001, Cordo col.; 1 male, Yarapa, Yarapa, 04°28'56"S, 73°23'39"W, on *P. crassipes*, 14-11-2001; Cordo col. **ARGENTINA:** 1 female, Formosa province, Subteniente Perin, 25°46'67"S, 59°88'33"W, on *P. cordata*, 15-12-1998, Sosa col.; 1 female, Herradura, 26°30'59"S, 58°16'54"W, on *P. crassipes*, 30-III-2016, Oleiro, Guala col., 4 males and 6 females, Palo Santo, 25°33'42.0"S, 59°19'10.6"W, on *P. subovata*, 15-04-2005, Sacco, col.; 1 male, La Florencia, 26°29'06.20"S, 58°18'16.65"W, on *P. crassipes*, 30-03-2016, Oleiro, Guala col.; 1 female, Irupe, on *P. crassipes*, 05-05-2016, Oleiro, Jastrzebski col. (MLPA).

***Cuernavaca longula* (Remes Lenicov):** Holotype male of *Taosa* (C.) *longula*, Argentina, Formosa, Herradura, on *P. crassipes*, 11-II-2004, Hernandez & Sacco, col.; Paratipo female, same data as Holotype; Paratipo male, Peru, Iquitos, Pururu Cocha, on *P. crassipes*, 29-IV-1999, Cordo col. (MLPA).

***Cuernavaca herbida* (Walker):** Holotype female of *Dichoptera herbida* Walker, Venezuela; 1 male of *Taosa herbida* (Walker), Costa Rica, Matina, 1912, Kirkaldy col., F. Muir, det.; 1 male of *Taosa herbida* (Walker), Trinidad, Uvarov, det.; 2 females, Atoyac, Vera Cruz, May H.H.S.; 3 males and 1 female, Teapa, Tabasco, Feb, H.H.S.; 1 female, Durango, Mexico; 1 female, Jalisco, Mexico; 1 female, Belize, Cayo; 1 male, San Gerónimo, Guatemala; 2 females, Matachin, Panamá; 1 male, Trinidad; 1 female, Dumont, San Pablo, Brasil; 11-VII-1923; G.L.R. Hancock (BMNH). 1 male, El Salvador, La libertad, 04-XI-1958, Duret col., 788/93, MNHN (EH) 18724; 1 female, Ecuador, Quito, R. Benoist 1930. MNHN (EH) 18723. (MNHN).

## ACKNOWLEDGMENTS

We are grateful to Mike Webb (British Museum of Natural History, London, United Kingdom) for his kindness in allowing the study of the collections of *Taosa* species and arranging loans of type-material. To Thierry Bourgoïn (Muséum National d'Histoire Naturelle, Paris) for his kind attention and giving us the opportunity to visit the collection and also, to the Hemiptera technician Laurent Fauvre for taking and sending photos of some

of the species of the Museum collection. We thank Ted D. Center and Philipp Tipping (Invasive Plant Research Laboratory, Agricultural Research Service, United States Department of Agriculture (USDA-ARS-IPRL)), and the National Research Council (CONICET) and La Plata National University (UNLP) from Argentina for the support to visit BMNH and MNHN. We also appreciate the thoughtful and constructive suggestions from the reviewers that greatly improved the original manuscript. This work was partially supported by Fundación para el Estudio de Especies Invasivas (FuEDEI), La Plata National University (UNLP: grant N° 730) and by ANPCyT, PICT 2015-1910.

## REFERENCES

- Bartlett, C.R. 2018. *Planthoppers of North America*. <http://canr.udel.edu/planthoppers>. Access in: 01/12/18.
- Bennett, F. & Zwolfer, H. 1968. Exploration for natural enemies of the water hyacinth in northern South America and Trinidad. *Hyacinth Control Journal*, 7: 44-52.
- Bourgoïn, T. 1993. Female genitalia in Hemiptera Fulgoromorpha, morphological and phylogenetic data. *Annales de la Société Entomologique de France (Nouvelle Serie)*, 29: 225-244.
- Bourgoïn, T. 2016. *FLOW (Fulgoromorpha Lists on The Web): a world knowledge base dedicated to Fulgoromorpha*. Version 8, updated 2019-01-18. <http://hemiptera-databases.org/flow>.
- Bourgoïn, T.; Wang, R.; Asche, M.; Hoch, H.; Soulier-Perkins, A.; Stroiński, A.; Yap, S. & Szewo, J. 2015. From micropterism to hyperpterism: recognition strategy and standardized homology-driven terminology of the forewing venation patterns in planthoppers (Hemiptera: Fulgoromorpha). *Zoomorphology*, 134: 63-77.
- Center, T.; Hill, M.; Cordo, H. & Julien, M. 2002. Wateryacynth, In: van Driesche, R.; Blossey, B.; Hoddle, M.; Lyon, S. & Reardon, R. (Eds.). *Biological control of invasive plants in the eastern United States*. U.S. Department of Agriculture. Chapter 4, p. 41-64.
- Crutwell, R. 1973. Preliminary investigations on some insects causing minor damage to water hyacinth, *Eichhornia crassipes*. Report of the West Indian Station. Trinidad, Commonwealth Institute of Biological Control.
- Denno, R. & Perfect, T. 1994. *Planthoppers: their ecology and management*. New York, Springer. 782p.
- Distant, W.L. 1906. Rhynchotal notes. XL. *Annals and Magazine of Natural History, Serie 7*, 18(10): 349-356.
- Donovall, L.R. 2008. A generic revision of the new world Dictyopharinae (Hemiptera: Dictyopharidae). Newark, University of Delaware. 412p. (Master of Sciences).
- Emeljanov, A.F. 1969. Reclassification of planthoppers the subfamily Orgeriinae (Homoptera, Dictyopharidae) of the palaearctic fauna. *Entomologicheskoe Obozrenie*, 48: 324-339.
- Emeljanov, A.F. 1983. Nosatka iz mela Taïmyra (Insecta, Homoptera) [Dictyopharidae from the Cretaceous deposits on the Taïmyr Peninsula (Insecta, Homoptera)]. *Palontologicheskii Zhurnal*, 17: 79-85.
- Emeljanov, A.F. 1997. A new genus and species of the Dictyopharidae from Australia belonging to a new tribe (Homoptera, Cidagina). *Zoosystematica Rossica*, 6: 77-82.
- Emeljanov, A.F. 2008. New genera and new species of the family Dictyopharidae (Homoptera), with notes on the systematics of the subfamily Dictyopharinae. *Entomological Review*, 88: 296-328.
- Emeljanov, A.F. 2010. A new genus of the family dictyopharidae (Homoptera) from Argentina. *Entomological Review*, 90: 724-726.



- Emeljanov, A.F. 2011. Improved tribal delimitation of the subfamily Dictyopharinae and description of new genera and new species (Homoptera, Fulgoroidea, Dictyopharidae). *Entomological Review*, 91: 1122-1145.
- Emeljanov, A.F. 2014. A new tribe, a new genus, and a new species of the subfamily Dictyopharinae (Homoptera, Dictyopharidae) from Chile. *Entomological Review*, 94: 1323-1328.
- Fennah, R.G. 1945. The Fulgoroidea, or lanternflies, of Trinidad and adjacent parts of South America. *Proceedings of the United States National Museum*, 95: 411-520.
- Fennah, R.G. 1947. Notes on Neotropical Dictyopharidae and Synonymy in two other groups. *Smithsonian Miscellaneous Collections*, 107(11): 1-15.
- Hadley, A. 2011. *Combine ZP-Free image stacking software for depth of field correction*. <http://www.hadleyweb.pwp.blueyonder.co.uk/CZM/combinezm.htm>.
- Hernández, M.C.; Brentassi, M.E.; Sosa, A.J.; Sacco, J. & Elsesser, G. 2011a. Feeding behavior and spatial distribution of two planthoppers, *Megamelus scutellaris* (Delphacidae) and *Taosa longula* (Dictyopharidae), on water hyacinth. *Biocontrol Science and Technology*, 21: 941-952.
- Hernández, M.C.; Sacco, J. & Cabrera Walsh, G. 2011b. Biology and host preference of the planthopper *Taosa longula* (Hemiptera: Dictyopharidae), a candidate for biocontrol of water hyacinth. *Biocontrol Science and Technology*, 21: 1079-1090.
- Kirkaldy, G.W. 1913. On some new species of leafhoppers. Part 1. *Bulletin Hawaiian Sugar Planter's Association Experiment Station. Division of Entomology*, 12: 7-27.
- Krstić, O.; Cvrković, T.; Mitrović, M.; Toševski, I. & Jović, J. 2016. *Dictyophara europaea* (Hemiptera: Fulgoromorpha: Dictyopharidae): description of immatures, biology and host plant associations. *Bulletin of Entomological Research*, 106: 395-405.
- Maes, J.M. & O'Brien, L. 1988. Catalogo de los Fulgoroidea (Homoptera) de Nicaragua. *Revista Nicaragüense de Entomología*, 5: 1-95.
- Melichar, L. 1912. Monographie der Dictyopharidae (Homoptera). *Abhandlungen der K.K. Zoologisch-Botanischen Gesellschaft in Wien*, 7: 1-122.
- Metcalf, Z.P. 1945. Fulgoroidea (Homoptera) of Kartabo, Bartica District, Br, Guiana. *New York Zoological Society*, 30: 125-141.
- Metcalf, Z.P. 1946. *General catalogue of the Hemiptera, fascicle IV, Fulgoroidea, Part 8, Dictyopharidae*. Northampton, Mass., Smith College. 246p. DOI
- Muir, F. 1923. On the classification of the Fulgoroidea (Homoptera). *Proceedings of the Hawaiian Entomological Society*, 5: 205-247.
- Muir, F. 1931. New and little-known Fulgoroidea from South America. *Proceedings of the Hawaiian Entomological Society*, 7: 469-480.
- Pellegrini, M.O.O.; Horn, C.N. & Almeida, R.F. 2018. Total evidence phylogeny of Pontederiaceae (Commelinales) sheds light on the necessity of its recircumscription and synopsis of Pontederia L. *PhytoKeys*, 108: 25-83.
- Remes Lenicov, A.M.M. de & Hernández, M.C. 2010. A new species of *Taosa* (Hemiptera: Dictyopharidae) from South America associated with water hyacinth. *Annals of the Entomological Society of America*, 103: 332-340.
- Remes Lenicov, A.M.M. de; Hernández, M.C.; Brentassi, M.E. & Defea, B. 2012. Descriptions of immatures of the South American dictyopharid *Taosa* (C.) *longula* (Hemiptera: Fulgoroidea). *Journal of the Insect Science*, 12: 1-11.
- Sacco, J.; Cabrera Walsh, G.; Hernández, M.; Sosa, A.; Cardo, M. & Elsesser, G. 2013. Feeding impact of the planthopper *Taosa longula* (Hemiptera: Dictyopharidae) on water hyacinth, *Eichhornia crassipes* (Pontederiaceae). *Biocontrol Science and Technology*, 23: 160-169.
- Song, Z.-S.; Bartlett, C.R.; O'Brien, L.B.; Liang, A.-P. & Bourgoin, T. 2018. Morphological phylogeny of Dictyopharidae (Hemiptera: Fulgoromorpha). *Systematic Entomology*, 43: 637-658.
- Song, Z.-S.; Szewdo, J.; Wang, R.-R. & Liang, A.-P. 2016a. Systematic revision of Aluntiini Emeljanov, 1979 (Hemiptera: Fulgoromorpha: Dictyopharidae: Dictyopharinae): reclassification, phylogenetic analysis, and biogeography. *Zoological Journal of the Linnean Society*, 176: 349-398.
- Song, Z.-S.; Webb, M.D. & Liang, A.-P. 2016b. Phylogenetic analysis of the Oriental genera of Orthopagini Emeljanov, 1983 (Hemiptera: Fulgoromorpha: Dictyopharidae: Dictyopharinae), with a systematic revision of the genus *Centromeria* Stål, 1870. *Zoological Journal of the Linnean Society*, 178: 33-87.
- Song, Z.-S.; Webb, M.D. & Liang, A.-P. 2014. Systematic revision of the Oriental planthopper genus *Miasa* Distant (Hemiptera: Fulgoromorpha: Dictyopharidae), with description of a new genus from southern India. *Arthropod Systematics & Phylogeny*, 72: 137-164.
- Synave, H. 1969. Note sur le genre *Taosa* Distant (Dictyopharidae) et sur *Harmosma bivulneratum* Fennah (Eurybrachidae) (Homoptera Fulgoroidea). *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique*, 45: 1-17.
- Urban, J.M. & Cryan, J.R. 2009. Entomologically famous, evolutionarily unexplored: The first phylogeny of the lanternfly family Fulgoridae (Insecta: Hemiptera: Fulgoroidea). *Molecular Phylogenetics and Evolution*, 50: 471-484.
- Walker, F. 1851. *List of the specimens of Homopterous insects in the collection of the British Museum*. London. v. 1, 260p.
- Walker, F. 1858. *Insecta saundersiana: or, characters of undescribed insects in the collection of William Wilson Saunders*. London, J. Van Voorst. 117p.
- Wilson, S. & O'Brien, L. 1987. A survey of planthopper pests of economically important plants (Homoptera: Fulgoroidea). In: International Workshop on Leafhoppers and Planthoppers of Economic Importance, 2°. *Proceedings*. London, CAB International Institute of Entomology. p. 343-360.
- Wilson, S.; Mitter, C.; Denno, R. & Wilson, M. 1994. Evolutionary patterns of host plant use by delphacid planthoppers and their relatives. In: Denno, R. & Perfect, T. (Eds.). *Planthoppers: their ecology and management*. New York, Chapman & Hall. p. 7-113.